M.E. First Semester Mechanical Engg. (Thermal Engg.) (New-CGS)

13508 : Advanced Heat Transfer : 1 MTE 4

P. Pages : 3
Time : Three Hours

AX - 3531
Max. Marks : 80

Notes :
1. All question carry marks as indicated.
2. Answer **three** question from Section A and **three** question from Section B.
3. Due credit will be given to neatness and adequate dimensions.
4. Assume suitable data wherever necessary.
5. Illustrate your answer necessary with the help of neat sketches.
6. Use of Heat & Mass Transfer data book is permitted.
7. Use of pen Blue/Black ink/refill only for writing the answer book.

SECTION – A

1. a) Explain Gauss-seidel iteration method for 2D temperature distribution. Also enlist its advantages and limitation. **6**

b) The composite wall of an oven consists of three materials, two of which are of known thermal conductivity, $K_A = 20\, W/mK$ and $K_C = 50 W/mK$ and known thickness, $L_A = 0.3m$ and $L_C = 0.15m$. The Third material, B, which is sandwiched between material A & C, is of known thickness, $L_B = 0.15m$ under steady state, measurement shows outer surface temperature of 20°C, an inner surface temperature of 600°C, and oven air temperature of 800°C. The inside convection coefficient $h = 25 W/m^2K$. what is the value of $K_B = ?$. **7**

2. a) Determine the optimum shape of Fin having the minimum weight for a given heat flow. Explain how the triangular fin is of the best shape. **7**

b) An electrically heated sphere with diameter D = 6cm is exposed to ambient air at $T_\infty = 25°C$ providing a heat transfer coefficient of $20 W/m^2K$. The surface of the sphere is tobe maintained at temperature $T_L = 125°C$. Calculate the heat loss for the following cases **6**

a) The bore sphere (uninsulated)

b) Sphere covered with an insulation $(K = 1W/m \cdot K)$ having a radius corresponding to critical radius.

3. a) With neat diagram explain Schmidt's method with no convective resistance. **6**

b) Along 20cm diameter cylindrical shaft made of stainless steel 304, comes out of an oven at a uniform temperature of 600°C. The shaft is then allowed to cool in an environment chamber at 200°C with an average heat transfer coefficient of $80 W/m^2 °C$. Determine the temperature at the center of the shaft 45min after the start of the cooling process. Also determine the heat transfer per unit length of the shaft during this time period. **8**

$\left(k = 14.9 W/mk,\ C_P = 477 J/kgK,\ \rho = 7900 kg/m^3\right)$

4. a) Derive a similarity solution for laminar flow over an isothermal flat plate. 6

b) Lubricating oil at a temperature of 60°C enters a 1cm diameter tube with velocity 3.5m/s. The tube surface is maintained at 30°C. Calculate the tube length required to cool the oil to 45°C. Assume that the oil has following average properties for the given temperature range. 7

$\rho = 865\,kg/m^3$, $K = 0.14\,W/mk$

$C_P = 1.78\,kJ/kg\,K$, $\nu = 9 \times 10^{-6}\,m^2/s$

5. a) Explain the graphical method of solving two dimensional heat conduction problem. 6

b) An aluminium plate heated to uniform temperature of 227°C is allowed to cool while being vertically suspended in a large room where the ambient air and surrounding temperature is 27°C. The Plate is 0.3m square with a thickness of 15mm and emissivity of 0.25. Develop an expression for time rate of change of the plate temperature, assuming the plate temperature to be uniform. Also, determine the initial rate of cooling (K/s) of the Plate when the plate temperature is 227°C. Justify the assumption of uniform temperature. 7

Aluminium : $\rho = 2770\,kg/m^3, k = 186\,W/mk$

$C_P = 0.983\,kJ/kg\,K$

Air at 400k and 1atm: $\nu = 24.61 \times 10^{-6}\,m^2/s$

$k = 0.0388\,W/mk$, $Pr = 0.69$.

SECTION – B

6. a) Define shape factor and discuss the following laws of shape factor. 6

i) Shape factor with respect to itself.

ii) Summation theorem

iii) Enclosure theorem

b) A surface of Area $0.5m^2$, emissivity 1.0 (perfect black body) and temperature of 150°C is placed in a large, evaluated chamber whose walls are maintained at 25°C What is the rate at which the radiation is emitted by the surface? What is the net rate at which radiation is exchanged between the surface and the chamber walls? 7

7. a) What do you mean by a radiation Shields? Where it is used? 6

b) In a cylindrical furnace of diameter 2m and height 1m, the base and the top having emissivities 0.4 and 0.8, respectively are maintained at 700k and 500k, while the lateral surface approximating a black body is maintained at 400k. Determine the neat rate of radiation heat transfer at each surface during steady state operation. 8

8. a) Explain the term 'critical diameter of bubble', give the equation and discuss the same. **7**

b) Two very large parallel planes with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction in heat transfer when the polished aluminium radiation Shield $(\in = 0.04)$ is placed between them. **6**

9. a) What is the condensation Number? For vertical plate show : **6**

$$CO = 1.47\ Re^{-1/3}$$

b) What is film cooling and transpiration cooling? Discuss their applications. **7**

10. Water is tobe boiled at atm. pressure in a polished copper pan by means of electric heater. The bottom of copper pan is 0.4m in diameter and is kept at 120°C. Calculate, **13**

i) Power required to boil the water.

ii) Rate at which the water evaporate from the pan due to boiling process.

iii) Critical heat flux for these condition

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